THE CHEMICAL COMPOSITION OF FOREST FRUITS AND NUTS FROM PENNSYLVANIA [1]

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INTRODUCTION

In the interest of wildlife conservation it is important to know the nutritive values of the food products of the forest, especially those which are available for the building up of nutritive reserves during the fall, to carry the wildlife over the critical winter period. Only after the various mast and browse foods have been evaluated is it possible, by proper forest management, to encourage the growth of the more desirable species. These are not necessarily the most nutritious ones, however, but rather are those which combine availability, productivity, nutritive value, and a capacity to resist decay. Upon this knowledge, and that of the food habits of the animals of the forest, wildlife management must to a large extent depend.

This paper seeks to represent, by means of chemical analysis, the nutritive value of 35 mast products from central Pennsylvania.

In making this study it was recognized that the possibilities of representing food values by chemical analysis are limited, and that the most significant information on the subject can be had only as a result of the use of the food products by animals. The mast foods are so diverse in character, however, some being concentrated foods capable of furnishing large parts of animals' diets, while many more contain little nutriment, and normally serve only as minor components of highly complex diets, that the only practicable method of conducting a general survey of the subject was by chemical analysis.

METHODS

Beginning with the conventional feed analysis in terms of moisture, total nitrogen, ether extract, crude fiber, ash, and nitrogen-free extract, additional determinations of tannin, cellulose, lignin, available nitrogen, calcium, magnesium, and phosphorus were made.[2] Record was made (table 1) of the date and the approximate location of collection when this latter information was available. Three of the samples, namely, the nuts of the Italian chestnut, shellbark hickory, and hazel, were purchased in the market. The Italian chestnut was included with the idea that the analysis of this product might serve approximately to represent the American chestnut if and when it shall again attain a significant prominence as a mast food.

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[2] The materials analyzed were collected by L. J. Bennett, P. F. English, T. Kuhn, and R. McCain.

TABLE 1.—*Name, date of collection, source, and portion analyzed of the fruit and nut products examined*

FRUITS

Common name [1]	Scientific name [1]	Date collected	Source in Pennsylvania	Portion analyzed
Apple, crab	*Malus coronaria*	Sept. 29, 1938	Huntingdon County	Whole fruit.
Bittersweet	*Solanum dulcamara*	Oct. 13, 1938	Centre County	Fruit, without calix.
Blackberry	*Rubus occidentalis*	Aug. 2, 1939	do	Whole berries.
Blackberry, Bailey's	*Rubus baileyanus*	Aug. 1, 1939	do	Do.
Blackhaw	*Viburnum prunifolium*	Sept. 29, 1938	do	Whole berries, unripe.
Blueberry	*Vaccinium sp*	Aug. 1, 1939	do	Whole berries.
Cherry, wild	*Prunus virginiana*	Sept. 29, 1938	do	Whole fruit (1) and seeds (2).
Chokeberry, black	*Aronia melanocarpa*	July 31, 1939	do	Whole berries.
Chokeberry, red	*Aronia arbutifolia*	Oct. 18, 1939	do	Do.
Cucumbertree	*Magnolia acuminata*	Sept. 23, 1938	Warren County	Whole fruit, three-fourths ripe.
Deerberry	*Accinium stamineum*	Aug. 29, 1939	Centre County	Whole fruit, unripe.
Dogwood, panicled	*Cornus femina*	Oct. 13, 1938	do	Whole berries.
Dogwood, red-osier	*Cornus stolonifera*	Sept. 25, 1939	do	Whole berries, half ripe.
Elder, American	*Sambucus canadensis*	Sept. 26, 1939	do	Whole berries.
Grape, frost	*Vitis cordiofolia*	Oct. 13, 1938	Huntingdon County	Whole fruit.
Hackberry	*Celtis occidentalis*	Nov. 2, 1939	Centre County	Whole berries.
Hawthorn, cockspur	*Crataegus crus-galli*	Oct. 13, 1938	do	Whole fruit.
Juneberry	*Amelanchier canadensis*	July 7, 1939	do	Whole berries.
Mountain-ash, American.	*Sorbus americana*	Sept. 29 1938	Huntingdon County	Do.
Mountain-holly	*Nemopanthus mucronata*	Aug. 10, 1939	Centre County	Do.
Nannyberry	*Viburnum lentago*	Sept. 25, 1939	do	Whole berries, nearly ripe.
Spicebush	*Benzoin aestivale*	Sept. 29, 1938	Huntingdon County	Fleshy part (1), and seeds (2).
Sumac, smooth upland	*Rhus glabra*	Sept. 29, 1938	Centre County	Whole berries.
Sumac, staghorn	*Rhus hirta*	Oct. 18, 1939	do	Do.
Winterberry, Virginia	*Ilex verticillata*	Oct. 17, 1939	do	Do.

NUTS

Buckeye, fetid	*Aesculus glabra*	Sept. 25, 1939	Centre County	Kernels.
Chestnut, Italian	*Castenea vulgaris*		Open market	Do.
Hazelnut	*Corylus americana*	Sept. 3, 1938	Centre County	Do.
Hickory, shell-bark	*Hicoria ovata*		Open market	Do.
Oak, red	*Quercus rubra*	Oct. 20, 1938	Warren County	Kernels, with integument.
Oak, rock chestnut	*Quercus prinus*	Oct. 7, 1938	Huntingdon County	Do.
Oak, scrub	*Quercus ilicifolia*	Sept. 29, 1938	do	Do.
Oak, scrub chestnut	*Quercus prinoides*	Sept. 25, 1939	Centre County	Do.
Oak, white	*Quercus alba*	Oct. 13, 1938	do	Do.
Walnut, black	*Juglans nigra*		Open market	Kernels.

[1] Authority: BRITTON, NATHANIEL LORD, and BROWN, ADDISON. AN ILLUSTRATED FLORA OF THE NORTHEASTERN UNITED STATES, CANADA AND THE BRITISH POSSESSIONS, FROM NEWFOUNDLAND TO THE PARALLEL OF THE SOUTHERN BOUNDARY OF VIRGINIA AND FROM THE ATLANTIC OCEAN WESTWARD TO THE 102D MERIDIAN. Ed. 2, rev. and enl., 3 v., illus. 1936. [N. Y. Bot. Gard.]

As the materials were received they were either immediately prepared for analysis or were stored for a limited time in sealed containers in refrigerating rooms. The fruits and berries were stored at approximately 40° F. and the nuts at temperatures below freezing.

In preparation for preliminary drying the fleshy fruits were sliced, and the nut kernels were cut into small pieces. The former were then dried in an air oven at approximately 50° C., and the latter in a vacuum oven at room temperature with reduced air pressure.

In the case of the wild cherry, separate analyses were made of the whole berries and of the seeds; and in the case of spicebush berries separate analyses were made of the outer fleshy integument and the seeds. The figures for the pulp and skin of the wild cherry, and for the whole spicebush berry, were calculated from the parts analyzed.

The oven-dry materials were transferred to a screened cabinet in which they were allowed to come to equilibrium with the moisture of the air. After 7 to 10 days they were weighed, and the loss of moisture from the fresh to the air-dry state was recorded.

The air-dry samples were ground in a meat chopper, and then extracted for 48 hours, the oily products (nuts, spicebush berry, etc.) with ether, and the sugary substances (blueberry, blackberry, etc.) with 95-percent ethyl alcohol. The air-dry residues were then ground in a micro Wiley mill, to pass a 20-mesh sieve, after which they were recombined, quantitatively, with their respective extracts.

The recombined materials were again dried in the air oven to remove the solvent, and were then rubbed through a 20-mesh sieve. Finally they were placed in the screened cabinet, and allowed once more to come into equilibrium with the moisture of the air; and after 7 to 10 days were bottled and sealed in readiness for analysis.

The methods of the Association of Official Agricultural Chemists (*1*) [3] were followed in the determination of moisture, total nitrogen, ether extract, crude fiber, total ash, nitrogen-free extract, tannin, calcium, magnesium, and phosphorus.

In determining moisture the samples were dried for 21 days in vacuum desiccators, without heat, in the presence of sulfuric acid. The samples thus dried were used in the determination of ether extract.

In employing the Kjeldahl-Gunning-Arnold method for total nitrogen, 4-percent boric acid was used as the receiving liquid, as proposed by Winkler (*7*).

Available protein was determined by the method of Horwitt, Cowgill, and Mendel (*4*), but this procedure was found not to be especially well adapted to the routine analysis of mast products because of excessive frothing during digestion.

Lignin was determined by the method of Ross and Hill (*6*) as modified first by Crampton and Maynard (*2*), and later by Crampton [4] by the use of Whatman, No. 50, acid-hardened filter paper in place of bolting cloth, and of preignited Celite Analytical Filter-Aid in place of the granulating agent consisting of chloroform and acetic acid. Cellulose was determined by the method of Kirschner and Hanak (*5*) as applied by Crampton and Maynard (*2*) to feeding stuffs.

ANALYTICAL RESULTS

The results of the chemical analyses of the mast products are given in table 2 expressed on the dry basis, and in table 3 on the fresh basis. Comments will be made on the former alone, since, from the nutritive point of view, the moisture contained in the materials is simply a variable diluent.

[3] Italic numbers in parentheses refer to Literature Cited, p. 635.
[4] Unpublished data.

The sum of the values for lignin and cellulose was invariably higher (124 to 543 percent) than the single figure for crude fiber. This may be due to a loss of cellulose during the acid and alkali digestions involved in the determination of crude fiber; or the values for lignin and cellulose may conceivably be improperly high as a result of undetermined impurities.

The content of available protein was less than the crude protein in all products, indicating the presence of some fat-soluble, nitrate, amide or ammonia nitrogen. The error of regarding nonprotein nitrogen as protein nitrogen is of less significance when the foods are used by ruminants than when they are used by nonruminants, because the former have the capacity to utilize nitrogen from sources other than protein—presumably by virtue of the synthetic capacities of the bacteria of the rumen.

TABLE 2.—*Percentage analyses (dry basis) of the fruit and nut products examined*

FRUITS, DRY BASIS

Common name	Crude protein	Ether extract	Crude fiber	Total ash	N-free extract	Available protein	Lignin	Cellulose	Tannin	Calcium	Magnesium	Phosphorus
Apple, narrowleafed crab	5.56	6.19	16.95	3.16	68.14	4.00	11.89	15.48	4.71	0.02	0.09	0.17
Bittersweet	15.19	28.77	8.26	3.44	44.34	11.88	8.98	10.22	1.35	.27	.29	.36
Blackberry	8.19	7.58	21.43	3.12	59.68	6.63	31.73	13.52	1.72	.15	.14	.21
Blackberry, Bailey's	6.75	6.08	24.14	4.31	58.72	5.56	28.58	15.49	2.04	.12	.17	.12
Blackhaw	4.13	11.93	10.28	2.58	71.08	3.69	24.68	7.70	5.94	.05	.08	.13
Blueberry	4.19	3.80	9.67	1.44	80.90	2.75	13.85	7.97	1.28	.04	.07	.07
Cherry, wild, whole	6.75	6.26	20.85	2.84	63.30	5.75	18.65	12.92	.60	.16	.07	.16
Cherry, wild, seeds	13.13	15.70	50.85	1.57	18.75	11.25	38.29	25.28	------	.18	.08	.19
Cherry, wild, pulp and skin	5.13	3.89	13.31	3.15	74.52	4.31	13.70	9.81	.75	.16	.07	.16
Chokeberry, black	5.00	3.44	12.56	2.71	76.29	4.19	39.80	9.80	3.78	.25	.12	.13
Chokeberry, red	5.25	3.80	9.24	2.52	79.19	4.38	36.13	8.48	7.31	.22	.21	.13
Cucumbertree	7.50	21.99	28.39	4.90	37.22	6.19	16.56	19.84	2.60	.23	.14	.20
Deerberry	3.75	5.45	11.17	1.62	78.01	2.50	11.46	8.57	1.71	.05	.05	.05
Dogwood, panicled	6.88	26.73	25.76	3.36	37.27	5.88	20.62	11.21	1.46	.21	.09	.15
Dogwood, red osier	6.94	12.02	26.42	3.40	51.22	5.56	27.12	12.01	1.58	.27	.19	.22
Elder, American	11.06	12.94	17.93	5.52	52.55	8.38	15.36	10.54	2.71	.13	.21	.36
Grape, frost	5.38	.87	13.43	2.75	77.57	4.19	14.50	7.45	1.99	.06	.08	.15
Hackberry	8.25	4.37	7.09	27.35	52.94	7.13	8.04	5.89	.82	12.42	.49	.22
Hawthorn, cockspur	2.81	3.29	32.83	3.69	57.38	2.56	20.44	23.32	3.39	.42	.10	.04
Juneberry	8.06	4.45	12.27	3.70	71.52	6.50	16.03	14.93	.41	.34	.21	.19
Mountain-ash, American	5.44	4.66	8.02	3.10	78.78	4.25	9.57	6.87	4.08	.10	.13	.16
Mountain holly	7.06	7.71	18.45	2.23	64.55	5.81	17.27	14.49	.96	.13	.13	.12
Nannyberry	4.13	8.88	7.18	2.06	77.75	3.63	32.32	6.69	1.57	.12	.04	.14
Spicebush, whole	11.94	50.73	5.23	5.74	26.36	9.94	4.04	5.98	1.35	------	.13	.30
Spicebush, seeds	18.19	56.21	7.45	2.20	15.95	17.06	5.21	4.91	.58	------	.16	.38
Spicebush, pulp and skin	8.56	47.82	4.05	7.62	31.95	6.13	3.41	6.54	1.75	------	.11	.26
Sumac, smooth upland	4.13	11.23	34.90	2.45	47.29	3.56	22.56	27.99	6.89	.16	.07	.16
Sumac, staghorn	5.44	14.54	30.31	3.01	46.70	4.88	21.66	27.50	4.41	.30	.15	.25
Winterberry, Virginia	6.13	5.10	15.57	2.62	70.58	5.31	9.49	12.61	.68	.13	.18	.10

NUTS, DRY BASIS

Buckeye, fetid	12.63	6.13	2.48	4.81	73.95	11.44	1.42	3.21	------	0.11	0.16	0.52
Chestnut, Italian	6.88	3.34	2.42	3.05	84.31	5.69	.38	3.69	0.19	------	.07	.15
Hazelnut	26.50	61.40	2.16	2.76	7.18	23.88	1.22	3.91	------	.29	.17	.40
Hickory, shell bark	13.31	74.36	1.51	2.01	8.81	12.13	.74	2.63	.48	(1)	.16	.37
Oak, red	6.56	20.81	3.10	2.42	67.11	6.13	2.99	4.14	9.77	(1)	.07	.14
Oak, rock chestnut	6.94	5.05	2.62	2.22	83.17	6.25	2.50	3.53	10.43	(1)	.09	.15
Oak, scrub	10.25	19.99	3.00	2.12	64.64	9.56	4.00	3.76	11.28	(1)	.14	.19
Oak, scrub chestnut	7.63	6.30	2.42	1.98	81.67	6.88	6.56	3.19	4.43	.07	.08	.15
Oak, white	6.25	6.32	2.47	2.64	82.32	6.00	2.64	3.24	5.58	(1)	.10	.16
Walnut, black	29.25	60.23	1.03	2.76	6.73	27.06	.87	2.01	.25	(1)	.27	.59

TABLE 3.—*Percentage analysis of the fruit and nut products examined*

FRUITS, FRESH BASIS

	Moisture	Crude protein	Ether extract	Crude fiber	Total ash	N-free extract	Available protein	Lignin	Cellulose	Tannin	Calcium	Magnesium	Phosphorus
Apple, narrowleaf crab	87.0	0.75	0.80	2.20	0.41	8.84	0.50	1.55	2.01	0.61	0.01	0.01	0.02
Bittersweet	66.3	5.13	9.69	2.78	1.16	14.94	4.00	3.02	3.44	.45	.09	.10	.12
Blackberry	80.9	1.56	1.45	4.10	.60	11.39	1.25	6.06	2.58	.33	.03	.03	.04
Blackberry, Bailey's	79.6	1.38	1.24	4.93	.88	11.97	1.13	5.84	3.17	.42	.02	.04	.02
Blackhaw	57.1	1.75	5.12	4.41	1.11	30.51	1.56	10.59	3.31	2.55	.02	.03	.06
Blueberry	85.3	.63	.56	1.42	.21	11.88	.50	2.04	1.17	.19	.01	.01	.01
Cherry, wild, whole	64.5	2.38	2.22	7.41	1.01	22.48	2.06	6.63	4.59	.21	.06	.02	.06
Cherry, wild, seeds	11.5	11.56	13.90	45.02	1.39	16.63	9.94	33.90	22.38	------	.16	.07	.17
Cherry, wild, pulp and skin	75.6	1.25	.95	3.25	.77	18.18	1.06	3.35	2.40	.18	.04	.02	.04
Chokeberry, black	75.6	1.25	.84	3.07	.66	18.58	1.00	9.72	2.39	.92	.06	.03	.03
Chokeberry, red	65.6	1.81	1.31	3.18	.87	27.23	1.50	12.43	2.92	2.51	.07	.07	.05
Cucumbertree	73.0	2.00	5.94	7.67	1.32	10.07	1.69	4.48	5.36	.70	.06	.04	.06
Deerberry	83.2	.63	.92	1.88	.27	13.10	.44	1.93	1.44	.29	.01	.01	.01
Dogwood, panicled	57.0	2.94	11.49	11.07	1.45	16.05	2.50	8.86	4.82	.63	.09	.14	.07
Dogwood, red-osier	68.4	2.19	3.79	8.34	1.07	16.21	1.75	8.56	3.79	.50	.09	.06	.07
Elder, American	76.4	2.63	3.06	4.24	1.30	12.37	2.00	3.63	2.49	.64	.03	.05	.08
Grape, frost	69.6	1.63	.26	4.08	.84	23.59	1.25	4.41	2.27	.61	.02	.03	.05
Hackberry	21.4	6.50	3.43	5.57	21.50	41.60	5.56	6.32	4.63	.64	9.76	.38	.17
Hawthorn, cockspur	62.0	1.06	1.25	12.48	1.40	21.81	1.00	7.77	8.86	1.29	.16	.04	.05
Juneberry	80.7	1.56	.86	2.37	.71	13.80	1.25	3.10	2.88	.08	.07	.04	.04
Mountain ash, American	73.7	1.44	1.23	2.11	.82	20.70	1.13	2.52	1.81	1.07	.03	.03	.04
Mountain-holly	59.2	2.88	3.15	7.53	.91	26.33	2.38	7.04	5.91	.39	.05	.05	.05
Nannyberry	53.8	1.94	4.11	3.32	.95	35.88	1.69	14.94	3.09	.73	.05	.02	.06
Spicebush, whole	62.3	4.50	19.14	1.97	2.17	9.92	3.75	1.52	2.26	.51	------	.05	.11
Spicebush, seeds	28.4	13.00	40.26	5.33	1.58	11.43	12.25	3.74	3.51	.42	------	.11	.27
Spicebush, pulp and skin	77.8	1.94	10.62	.90	1.69	7.05	1.38	.76	1.45	.39	------	.03	.06
Sumac, smooth upland	8.1	3.81	10.32	32.07	2.25	43.45	3.25	20.73	25.72	6.33	.15	.06	.15
Sumac, staghorn	8.0	5.00	13.37	27.87	2.77	42.99	4.50	19.92	25.29	4.06	.28	.14	.23
Winterberry, Virginia	68.6	1.94	1.60	4.88	.82	22.16	1.69	2.98	3.96	.21	.04	.06	.03

NUTS, FRESH BASIS

Buckeye, fetid	52.7	6.00	2.90	1.17	2.27	34.96	5.44	0.67	1.52	------	0.05	0.08	0.25
Chestnut, Italian	33.1	4.63	2.23	1.62	2.04	56.38	3.81	.25	2.47	0.13	------	.05	.10
Hazelnut	2.6	25.81	59.80	2.10	2.69	7.00	23.25	1.19	3.81	------	.28	.17	.39
Hickory, shellbark	2.2	13.00	72.72	1.48	1.97	8.63	11.88	.72	2.57	.47	(1)	.16	.36
Oak, red	38.2	4.06	12.87	1.92	1.50	41.45	3.81	1.85	2.56	6.04	(1)	.05	.08
Oak, rock chestnut	50.1	3.44	2.52	1.31	1.11	41.52	3.13	1.25	1.76	5.20	(1)	.04	.08
Oak, scrub	42.0	5.94	11.61	1.74	1.23	37.48	5.56	2.32	2.18	6.55	(1)	.08	.11
Oak, scrub chestnut	44.2	4.25	3.52	1.35	1.11	45.57	3.81	3.66	1.78	2.47	.04	.04	.09
Oak, white	47.3	3.31	3.33	1.30	1.39	43.37	3.13	1.39	1.71	2.94	(1)	.05	.08
Walnut, black	2.9	28.38	58.48	1.00	2.68	6.56	26.25	.84	1.95	.24	(1)	.26	.57

[1] Trace.

The values for nitrogen-free extract are of more indefinite significance than usual because they include the questionable tannin fraction, which reaches a maximum of 11.28 percent in the acorn of the scrub oak.

A lignin determination on the cellulose of the blackhaw revealed that a considerable portion of the lignin had not been removed during the acetic acid-nitric acid digestion. The percent of cellulose in the moisture-free sample was 7.70, and of this total approximately 16 percent appeared as lignin. Whether this means that the acid

digestion is incomplete, or that the lignin value is only an apparent one, remains to be determined.

FRUITS

Unless otherwise stated, the seeds of fleshy fruits were ground in with the remainder. This obviously gives consistent results for the products as used by animals which themselves grind the seeds, but yields improperly high results with animals which do not grind the seeds.

The fruits are predominantly carbohydrate foods; many are high in lignin and cellulose, and some are rich in protein and fat, mainly because of their seeds.

The bittersweet berry consists mainly of thin-walled seeds, with a thin covering of flesh of high moisture content. Its very high content of protein and ether extract, and relatively high content of mineral nutrients, constitute it a decidedly concentrated foodstuff.

The fruits of two species of blackberry, which are of much the same physical character as the bittersweet berry, appear to be of lower nutritive value. The composition, as stated here, represents the value of the blackberry to animals that grind the small, hard seeds and thus expose the kernels to digestion. The blackberry contains appreciable quantities of all the classes of nutrients determined, but is most notable for its high cellulose and lignin content.

The blueberry, deerberry, and juneberry are mainly carbohydrate foods. Aside from their content of nitrogen-free extract they are of moderately low value.

The value of the wild cherry depends largely on whether the shells are broken and the kernels utilized. The pulp and skin are relatively poor in protein and fat, but rich in nitrogen-free extract, while the seeds are moderately rich in protein, decidedly rich in fat, and poor in nitrogen-free extract. The pulp and skin are similar in composition to that of the blueberry, the deerberry, and the juneberry.

The berries of the mountain-ash and the two chokeberries contain nearly 80 percent of nitrogen-free extract, as well as approximately 5 percent each of crude protein and ether extract and therefore must be regarded as decidedly useful winter foods for animals to which they are acceptable. Both of the chokeberries contain high percentages of lignin.

The narrowleaf crab apple also is mainly a carbohydrate food, being relatively poor in protein, ether extract, and mineral nutrients, and rich in nitrogen-free extract. The high content of cellulose, lignin, and tannin are more suggestive of bark than of fruit. The product, however, appears to be characterized by a considerable value for purposes of maintenance.

In spite of its high crude-fiber content the fruit of the cucumbertree appears to be of high nutritive value to those animals that accept it. The ether extract is high, but the dense cellulosic network which lends rigidity to the fruit and its aromatic odor may render the fruit unacceptable to some animals.

The deerberry is a low-protein, low-fat, predominantly carbohydrate food, with no outstanding nutritive peculiarities.

The fruits of dogwoods, especially the panicled dogwood, are high in ether extract, and they have only a moderate content of protein and

mineral nutrients. The crude-fiber content is high, but not so high as to prevent these products from being important winter reserve foods.

The berry of the American elder has a composition that makes it nutritionally superior even to those of the dogwoods. Its lower crude fiber is associated not, as in many products, with a high content of nitrogen-free extract, but with a relatively high content of protein. The ether extract, although not as high as that of the panicled dogwood, is still higher than that of the red-osier dogwood.

The physical characteristics and composition of the frost grape place it in a class with the wild cherry pulp and skin, except that the ether extract is remarkably low. This means that it is mainly a carbohydrate food and therefore of value principally for maintenance purposes. As with other fruits containing a large proportion of seeds to pulp, the value of the frost grape depends largely on the method by which the animal disposes of the seed.

The hackberry is remarkable because of its unusual content of ash, and also of calcium, which, on the dry basis, amounts to 12.42 percent. Magnesium also occurs in an amount greater than in any other fruit or berry. The other constituents are present in moderate quantities, with the exception of lignin and cellulose, which are relatively low. Its magnesium content is twice as high as its phosphorus.

To those animals that can avail themselves of the whole fruit (flesh and seed) the blackhaw is moderately nutritious. It is most notable for its low protein and high lignin and tannin content.

The fruits of the mountain-holly, juneberry, mountain-ash, nannyberry, and winterberry are low-protein, low-fat products with the relatively high carbohydrate content usual among fruits.

The spicebush berry, whether whole or divided between pulp and skin, and seed, is unusual in that it contains approximately 50 percent of ether extract. This extract, however, is highly aromatic and may render the berry unacceptable to some animals. The content of protein is above average, while the percentages of crude fiber and nitrogen-free extract are decidedly low. This berry, therefore, possesses a decidedly high potential nutritive value.

The sumac berries also are rich in ether extract, though not nearly so rich as the berry of the spicebush. Their content of crude fiber is high, and the sum of the lignin and cellulose fractions amounts to approximately 50 percent. The nutritive value of these sumacs is presumably further lowered by their high content of tannin, but a positive qualification of sumac berries is the fact that they are unusually resistant to decay and therefore may serve as important food reserves, especially during the later winter months, when food is scarce.

That sumac berries are efficiently utilized, however, cannot be assumed with confidence, since Errington (*3*) found that not only sumac but also bittersweet berries, rose hips, dried wild grapes and sweetclover seed, individually, failed to maintain captive bobwhites. At the same time it should be realized that maintenance on a single food is a severe test that many useful products cannot satisfy, and that a normally efficient diet might readily be made up of a variety of foods no one of which, by itself, is capable of maintaining the animal consuming it.

The cockspur hawthorn fruit is a decidedly inferior foodstuff. It is deficient in protein and fat, high in crude fiber, and relatively low in nitrogen-free extract. Furthermore, the nitrogen-free extract includes a considerable proportion of tannin.

NUTS

The analyses of all of the nuts represent the kernels only, the hulls being considered as without value.

Nuts in general are characterized by their concentration, as sources of nutriment, but there is much diversity in their content of protein, carbohydrate, and fat. The kernels are all low in lignin and cellulose.

Among the species analyzed, the black walnut, the hickory nut, and the hazelnut are in a class by themselves as high-protein, high-fat, and low-carbohydrate foods, with the hickory nut containing only about half as much protein as the walnut and the hazelnut, but decidedly more fat. The percentage composition of these three nuts is suggestive of that of animal flesh.

The chestnut and the acorns are relatively low in protein, crude fiber, and phosphorus, but contain substantial amounts of available carbohydrate. Three of the five acorns are also low in fat.

The nuts analyzed were all exceedingly low in calcium, the hazelnut being the highest in this constituent, and were also low in phosphorus; but among these species the buckeye, hazelnut, hickory nut, and black walnut were richer in this element than were the chestnut and the acorns. The buckeye was richest of all in ash.

The acorns were all high in tannin content, the red oak, rock chestnut oak, and scrub oak being the highest. The nutritive status of tannin, for wildlife, remains to be determined. Obviously foods which are rich in this constituent are acceptable to many kinds of animals, but not to others.

SUMMARY

Chemical analyses are presented of 35 mast foods, the conventional food analysis being supplemented by determinations of tannin, cellulose, lignin, available protein, calcium, magnesium, and phosphorus.

The sum of the lignin and cellulose fractions was invariably found to be higher than the value determined for crude fiber.

In all products the content of available protein was less than that of crude protein.

The values for nitrogen-free extract of mast foods are of more questionable significance than the corresponding values for foodstuffs in general because they include the tannin fraction, which reached a maximum of 11.28 percent, on the dry basis, in the acorn of the scrub oak.

The fruits and berries are, for the most part, relatively rich in nitrogen-free extract and much less rich in protein and ether extract. They are of only moderate nutritive value, and serve mainly for energy production. The nuts are of greater value, especially because of their content of protein and fat.

In contrast to most fleshy fruits, those of bittersweet, cucumber-tree, panicled dogwood, and spicebush are remarkably rich in ether extract, and are, therefore, relatively concentrated foods.

The hazelnut, hickory nut, and black walnut are very concentrated foods, containing much ether extract and protein, and very little nitrogen-free extract. Among nuts they are relatively rich in phosphorus. Almost all of the nuts analyzed were exceedingly low in calcium, and they usually contained much more magnesium than calcium.

Chestnuts, buckeyes, and most acorns are oil-poor and are relatively rich in nitrogen-free extract; they are not so rich in protein as are the oil-bearing nuts.

The products richest in tannin were the acorns, chokeberries, sumac berries, blackhaw, narrowleafed crab apple, and mountain-ash berries.

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